

The invention in which an exclusive right is claimed is defined by the following:

1. Apparatus for illuminating a portion of a body lumen to which a photoreactive agent has been or will be administered, comprising:

(a) an elongate, flexible body having a proximal end, a distal end, and at least one lumen extending therebetween;

(b) a light source array having a proximal end and a distal end, the light source array emitting light directed toward the distal end of the elongate, flexible body, said light having a characteristic emission waveband, where the characteristic emission band corresponds to a characteristic absorption waveband of the photoreactive agent;

(c) an electrical lead having a proximal end adapted to be electrically coupled to an external power supply, and a distal end electrically coupled to the light source array, thereby enabling the light source array to be energized with an electrical current when the proximal end of the electrical lead is electrically coupled to the external power supply; and

(d) a light diffusing element having a proximal end and a distal end, the proximal end of the light diffusing element being oriented in a facing relationship with the distal end of the light source array, such that light emitted from the light source array is diffused and directed outwardly away from the light diffusing element.

2. The apparatus of Claim 1, further comprising an optical fiber having a proximal end, a distal end, the proximal end of the optical fiber facing toward the distal end of the light source array, and the distal end of the optical fiber directing light from the light source array to the light diffusing element.

3. The apparatus of Claim 2, wherein the optical fiber is tapered, such that the distal end of the optical fiber has a smaller cross-section than the proximal end of the optical fiber.

4. The apparatus of Claim 2, wherein the optical fiber comprises a bundle of optical fibers.

5. The apparatus of Claim 1, further comprising an optical element having a proximal side and a distal side, the proximal side of the optical element facing toward the distal end of the light source array, and the optical element focusing light emitted from the light source array.

6. The apparatus of Claim 1, wherein the light diffusing element is generally cylindrical.

7. The apparatus of Claim 1, wherein the light diffusing element comprises a plurality of light diffusing members.

8. The apparatus of Claim 1, wherein the light source array comprises a plurality of light emitting devices and conductive traces electrically coupling the plurality of light emitting devices to the electrical lead, thereby enabling the light emitting devices to be energized with the electrical current from an external power source.

9. The apparatus of Claim 1, further comprising
(a) an expandable member substantially encompassing the light diffusing element; and
(b) an inflation lumen extending between the proximal end of the elongate, flexible body and the expandable member.

10. The apparatus of Claim 9, wherein the inflation lumen further extends between the distal and proximal ends of the light source array.

11. The apparatus of Claim 9, wherein the inflation lumen further extends between the elongate, flexible body and the light diffusing element, through any intervening element included in the apparatus.

12. The apparatus of Claim 1, wherein the light source array comprises reflective elements configured to reflect light emitted by the light source array toward the distal end of the light source array, increasing an intensity of light emitted from the distal end of the light source array.

13. Apparatus for illuminating a portion of a body lumen to which a photoreactive agent has been or will be administered, comprising:

(a) an elongate, flexible body having a proximal end and a distal end, and at least one lumen extending therebetween;

(b) a light source array having a distal end and a proximal end, the proximal end of the light source array being coupled to the distal end of the elongate, flexible body and including a flexible conductive substrate, and a plurality of light emitting device electrically coupled to the conductive substrate, the light source array being adapted to emit light having a characteristic emission waveband corresponding to a characteristic absorption waveband of the photoreactive agent;

(c) an electrical lead having a proximal end adapted to be electrically coupled to an external power supply, and a distal end electrically coupled to the flexible conductive substrate enables the light source array to be energized with an electrical current when the proximal end of the lead is electrically coupled to the external power supply, and

(d) a distal portion having a proximal end and a distal end, the proximal end of the distal portion being coupled to the distal end of the light source array, the distal portion including a first opening disposed on a sidewall of the distal portion, and a second opening disposed on the distal end of the distal portion, a lumen extending between the first opening and the second opening to enable the apparatus to be advanced over a guidewire.

14. The apparatus of Claim 13, wherein the plurality of light elements comprises a plurality of light emitting diodes.

15. The apparatus of Claim 13, wherein the light source array is encapsulated in a polymer that is substantially optically transparent to light of the characteristic absorption wavelength of the photoreactive agent.

16. The apparatus of Claim 14, wherein the light source array includes a first face and a second face substantially opposed to the first face, and wherein the plurality of light emitting devices are disposed on the first face and on the second face.

17. The apparatus of Claim 13, wherein the plurality of light emitting devices includes first light emitting devices and second light emitting devices, such that when energized with an electrical current, the first light emitting devices emit light having a first wavelength, and the second light emitting devices emit light having a second wavelength that is different than the first wavelength.

18. The apparatus of Claim 13, further comprising at least one light sensing element.

19. The apparatus of Claim 13, wherein the light source array includes strain relief features to increase a flexibility of the apparatus to bending.

20. The apparatus of Claim 13, further comprising:

(a) an expandable member substantially encompassing the light source array; and

(b) an inflation lumen extending between the proximal end of the elongate, flexible body and the expandable member, in fluid communication with a volume encompassed by the expandable member.

21. The apparatus of Claim 13, further comprising:

(a) a first expandable member disposed adjacent to the proximal end of the light source array;

(b) a first inflation lumen extending between the proximal end of the elongate, flexible body and the first expandable member and in fluid communication with a first volume encompassed by the first expandable member;

(c) a second expandable member disposed adjacent to the distal end of the light source array;

(d) a second inflation lumen extending between the proximal end of the elongate, flexible body and the second expandable member, and in fluid communication with a second volume encompassed by the second expandable member;

(e) a fluid port disposed between the first and second expandable members; and

(f) a flushing lumen extending between the proximal end of the elongate, flexible body and the fluid port.

22. The apparatus of Claim 21, further comprising at least one additional expanding member, each additional expanding member being disposed between the first and second expandable members, and encompassing another volume coupled in fluid communication with the second inflation lumen.

23. The apparatus of Claim 21, further comprising at least one additional expanding member, each additional expanding member being disposed between the first and second expandable members, and encompassing another volume that is coupled in fluid communication with an additional inflation lumen extending between the proximal end of the elongate, flexible body and the additional expandable member.

24. Apparatus for illuminating a portion of a body lumen to which a photoreactive agent has or will be administered, comprising:

(a) an elongate, flexible body having a proximal end, a distal end, and a plurality of lumens, said plurality of lumens including a first inflation lumen, a second inflation lumen, a flushing fluid lumen, and a working lumen;

(b) a first expandable member disposed adjacent to the distal end of the elongate, flexible body, the first expandable member encompassing a first volume in fluid communication with the first inflation lumen;

(c) a second expandable member disposed between the first expandable member and the proximal end of the elongate, flexible body, the second expandable member encompassing a second volume in fluid communication with the second inflation lumen;

(d) a fluid port disposed between the first and second expandable members, the fluid port being in fluid communication with the flushing fluid lumen; and

(e) a linear light source array disposed in the working lumen, the linear light source array extending substantially between the first and second expandable members and including an electrical lead adapted to couple to an external power supply, to enable the linear light source array to be energized with an electrical current, causing the light source array to emit light having a characteristic emission waveband, wherein the characteristic emission band corresponds to a characteristic absorption waveband of the photoreactive agent.

25. The apparatus of Claim 24, further comprising at least one additional expanding member, each additional expanding member being disposed between the first and second expandable members, and encompassing a different volume that is coupled in fluid communication with the second inflation lumen.

26. The apparatus of Claim 24, further comprising at least one additional expanding member, each additional expanding member being disposed between the first and second expandable members, and encompassing a different volume that is coupled in fluid communication with an additional different inflation lumen extending between the proximal end of the elongate, flexible body and the additional expandable member.

27. The apparatus of Claim 24, wherein the elongate, flexible body includes a first opening disposed on a sidewall of the elongate, flexible body adjacent to the distal end of the elongate, flexible body, and a second opening on the distal end of the elongate, flexible body, and a lumen extending between the first opening and the second opening, to enable the apparatus to be advanced over a guidewire that passes through the first opening and the second opening.

28. The apparatus of Claim 24, wherein the linear light source array is integrated into a guidewire that passes through the working lumen.

29. The apparatus of Claim 24, wherein each expandable member is formed integral to the elongate, flexible body.

30. Apparatus for illuminating a portion of a body lumen to which a photoreactive agent has or will be administered, comprising:

(a) an elongate, flexible body having a proximal end, a distal end, and at least one lumen; and

(b) a light source element disposed adjacent to the distal end of the elongate, flexible body, the light source element being electrically coupled to an electrical lead that is adapted to couple to an external power supply, to enable the light source element to be energized with an electrical current, thereby illuminating at least a portion of the body lumen, the light source element emitting light having a characteristic emission waveband corresponding to a characteristic absorption waveband of the photoreactive agent.

31. The apparatus of Claim 30, wherein the light source element includes a plurality of light sources.

32. The apparatus of Claim 31, wherein the plurality of light sources are each light emitting devices.

33. The apparatus of Claim 31, wherein the plurality of light sources are configured in a radial array.

34. The apparatus of Claim 31, wherein the plurality of light sources are configured in a linear array.

35. The apparatus of Claim 34, wherein the linear array includes a first planar surface and a second planar surface, said second planar surface being generally opposed to the first planar surface, and wherein the plurality of light sources are distributed over the first and second planar surfaces.

36. The apparatus of Claim 31, wherein the plurality of light sources include at least one first type of light source emitting light of a first wavelength, and a second type of light source emitting light of a second wavelength.

37. The apparatus of Claim 30, further comprising at least one light sensor.

38. The apparatus of Claim 30, wherein the light source element is disposed within a working lumen within the elongate, flexible body.

39. The apparatus of Claim 30, wherein the light source element is integrated into a guidewire.

40. The apparatus of Claim 30, wherein the light source element has a proximal end and a distal end, the proximal end of the light source element facing toward the distal end of the elongate, flexible body.

41. The apparatus of Claim 40, further comprising a light diffusing element having a proximal end, a distal end, the proximal end of the light diffusing element facing toward the distal end of the light source element, so that light emitted from the light source element is diffused and directed outwardly away from the light diffusing element.

42. The apparatus of Claim 41, further comprising

- (a) an expandable member substantially encompassing the light diffusing element; and
- (b) an inflation lumen extending between the proximal end of the elongate, flexible body and the expandable member, in fluid communication with a volume encompassed by the expandable member.

43. The apparatus of Claim 41, further comprising an optical fiber having a proximal end, and a distal end, the proximal end of the optical fiber facing toward the distal end of the light source element, and the distal end of the optical fiber facing toward the proximal end of the light diffusing element, the optical fiber directing light from the light source element to the light diffusing element.

44. The apparatus of Claim 43, wherein the optical fiber is tapered, such that the distal end of the optical fiber has a smaller cross-section than the proximal end of the optical fiber.

45. The apparatus of Claim 41, further comprising an optical element having a proximal side, and a distal side, the proximal side of the optical element facing toward the distal end of the light source element, said optical element focusing light emitted from the light source element.

46. The apparatus of Claim 40, further comprising a distal portion having a proximal end and a distal end, the proximal end of the distal portion being coupled to the distal end of the light source element, the distal portion including a first opening disposed on a sidewall of the distal portion, and a second opening disposed on the distal end of the distal portion, and a lumen extending between the first opening and the second opening, said lumen enabling the apparatus to be advanced over a guide wire that passes through the first opening and the second opening.

47. The apparatus of Claim 40, further comprising

- (a) an expandable member substantially encompassing the light source element; and
- (b) an inflation lumen extending between the proximal end of the elongate, flexible body and the expandable member, in fluid communication with a volume encompassed by the expandable member.

48. The apparatus of Claim 30, wherein the light source element comprises a linear light source array, and wherein the at least one lumen in the elongate, flexible body comprises a first inflation lumen, a second inflation lumen, a flushing fluid lumen, and a working lumen, further comprising:

(a) a first expandable member disposed adjacent to the distal end of the elongate, flexible body, the first expandable member encompassing a first volume in fluid communication with the first inflation lumen;

(b) a second expandable member disposed between the first expandable member and the proximal end of the elongate, flexible body, the second expandable member encompassing a second volume in fluid communication with the second inflation lumen; and

(c) a fluid port disposed between the first and second expandable members, the fluid port being in fluid communication with the flushing fluid lumen.

49. The apparatus of Claim 48, further comprising at least one additional expanding member, each additional expanding member being disposed between the first and second expandable members, and encompassing another volume coupled in fluid communication with the second inflation lumen.

50. The apparatus of Claim 48, further comprising at least one additional expanding member, each additional expanding member being disposed between the first and second expandable members, and encompassing a different volume that is coupled in fluid communication with a different additional inflation lumen extending between the proximal end of the elongate, flexible body and the additional expandable member.

51. A method for using photodynamic therapy to treat vascular tissue, comprising the steps of:

- (a) providing a vascular illumination apparatus comprising:
 - (i) an elongate, flexible body having a proximal end, a distal end, and at least one lumen; and
 - (ii) a light source element disposed adjacent to the distal end of the elongate, flexible body, the light source element, when energized, emitting light having a characteristic emission waveband;
- (b) administering a photoreactive agent to target vascular tissue in a patient, the photoreactive agent having a characteristic absorption waveband corresponding to the characteristic emission waveband of the light source element;
- (c) advancing the vascular illumination apparatus through the vascular system of the patient until the light source element is disposed adjacent to the vascular target tissue; and
- (d) energizing the light source element to administer light to the vascular target tissue, the application of light to the vascular target tissue resulting in at least one of a therapeutic effect and generation of diagnostic data.

52. The method of Claim 51, wherein before the step of energizing the light source element, further comprising the step of centering the vascular illumination apparatus within a blood vessel that includes the vascular target tissue.

53. The method of Claim 51, wherein before the step of energizing the light source element, further comprising the step of displacing a bodily fluid disposed between the light source element and the vascular target tissue, thereby preventing the bodily fluid from interfering with the transmission of light from the light source element to the target tissue.

54. The method of Claim 53, wherein the step of displacing the bodily fluid disposed between the light source element and the target tissue before the step of energizing the light source element comprises the step of inflating an expandable member that substantially encompasses the light source element until the expandable member contacts the walls of the vascular lumen adjacent to the target tissue, thereby displacing bodily fluid that could interfere with the transmission of light from the light source element to the target tissue.

55. The method of Claim 53, wherein the step of displacing the bodily fluid disposed between the light source element and the target tissue before the step of energizing the light source element comprises the steps of:

(a) inflating a first expandable member disposed distal of the light source element and a second expandable member disposed proximal of the light source element until the first and the second expandable members contact the walls of the vascular lumen adjacent to the target tissue; and

(b) replacing the bodily fluid trapped between the first expandable member and the second expandable member with a flush fluid.

56. The method of Claim 51, further comprising the step of diffusing the light emitted by the light source element that is administered to the vascular target tissue.

57. The method of Claim 51, further comprising the step of emitting light from the light source element along a linear path.

58. The method of Claim 51, further comprising the step of guiding the elongate, flexible body over a guide wire that includes the light source element.